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RESEARCH REPORT

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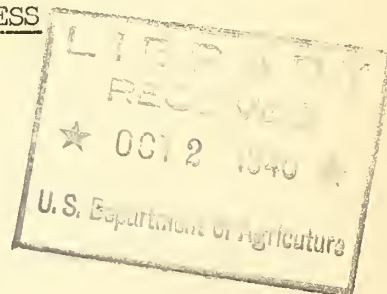
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SERVICE LIFE OF UNTREATED JUNIPER AND CYPRESS
FENCE POSTS IN ARIZONA

by

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SERVICE LIFE OF UNTREATED JUNIPER AND CYPRESS FENCE POSTS IN ARIZONA

Native juniper has been used for fence posts in the Southwest since pioneer days. Early settlers found that untreated juniper remained serviceable in the ground during a long period of years. As a result, juniper posts are now preferred over all other native woods by most users.

Cypress posts have also been used for many years, but their use has in most cases been confined to the restricted localities where the trees grow. More recently, however, cypress has been cut in commercial quantities, largely for highway fences.

KINDS OF JUNIPERS AND CYPRESSES

Four species of native junipers grow to a size suitable for fence posts. Of these, Utah juniper (Juniperus utahensis) and one-seed juniper (J. monosperma) are both widely distributed, and have been cut in the largest quantities. Both trees are commonly called cedar, and their posts are marketed under that name. Posts of alligator juniper (J. pachyphloea) have also been generally used in certain localities. The characteristic checkered bark of this species readily distinguishes it from the other native junipers, and it is the only one commonly called juniper. The fourth species, which is Rocky Mountain red cedar (J. scopulorum), is more limited in its distribution, and has not been extensively used for posts in Arizona.

Two cypresses are native to Arizona, namely, Arizona cypress (Cupressus arizonica) and smooth cypress (C. glabra) 2/. These two species are very similar; they are not distinguished by the average layman, and were not differentiated in this study.

NEED FOR FACTUAL INFORMATION

In spite of the fact that juniper is generally recognized as a superior fence-post material, there has been a lack of information, based on the results of systematic study, regarding the service life of juniper posts of different sizes and species, or the behavior of posts under different climatic and soil conditions. Even less is known concerning cypress posts. Inasmuch as conditions existed under which a trustworthy study could be made, because the data of the establishment of many old fences could be traced with reasonable accuracy, a study of fence posts of these two species was made during 1939.

LOCATION AND NUMBER OF FENCES EXAMINED

This study was restricted to round, untreated posts, in order

2/ The cypress of the Southwest (Cupressus sp.) should not be confused with the tree growing in the Gulf States, called Bald Cypress (Taxodium distichum), and known commercially as Southern Cypress and Tidewater Red Cypress, which is very durable untreated.

that the data on sizes and species would be comparable. The location and ages of fences suitable for the study were obtained in most cases through the cooperation of the local stockmen and Forest Service officers. Altogether, about 2,300 posts in 97 fences were carefully examined. Thirty-eight fences contained posts of Utah juniper; 31, of one-seed juniper; 18, of alligator juniper; and 10, of cypress. No fences with posts of Rocky Mountain red cedar were located. The juniper fences were widely scattered; 10 of the 14 counties in Arizona were represented. The counties not included are Mohave, Yuma, Santa Cruz, and Cochise. The cypress fences were all located in central Arizona, south of the Mogollon Rim.

SCOPE AND KIND OF FIELD DATA COLLECTED

For each fence, three factors were considered, namely, year when built, kind of post, and the general type of hazard to which the fence was subjected. Since temperature and moisture are the important factors in the susceptibility of wood to decay, and since these factors are rather definitely reflected in the predominate types of vegetation, four vegetational zones, representing four fairly distinct types of decay hazard, were recognized, as follows: (a) saw-timber zone (ponderosa pine type), where temperatures are low but moisture is relatively high; (b) woodland zone (pinon, juniper, oak, and chaparral associations), where temperatures and moisture are both intermediate; (c) desert zone (desert-shrub and desert-grassland associations), where temperatures are high but moisture low; and (d) irrigated lands (irrigated farms within desert zone), where both temperatures and moisture are high. These four zones are also altitudinal in location; the saw-timber at the highest elevation, and the desert and irrigated zones at the lowest. They may be regarded as climatic zones.

Individual examinations were made of about 25 posts in each of the 97 fences. These posts were taken in the order in which they occurred along the fence line, except that split posts, brace posts, and corner posts were omitted. The information recorded for each post included the following items:

1. Outside diameter)
2. Width of sapwood) at ground line
3. Diameter of heartwood core)
4. Condition of sapwood (sound, partly decayed, or entirely decayed)
5. Brief classification of site factors (slope, exposure, drainage, soil, and shade)
6. Condition of post (serviceable or unserviceable, as determined by ability to withstand a lateral pull of 100 pounds)

The outside diameter was measured with a tape, and the width of sapwood was measured with a steel rule in a 3/4-inch hole bored just above the ground line. The diameter of heartwood was assumed to be the outside diameter less twice the width of sapwood. Serviceability, based on 100-pound lateral pull, was determined by applying a

spring balance at a point 4 feet above the ground and at right angles to the fence line.

The distribution of the posts by species and length of service is shown in table 1.

Table 1. - Distribution of posts by species and length of service

Species	: Number of posts examined and tested of each 10-year						
	: age class since posts were set into the ground						
	: 10	: 20	: 30	: 40	: 50	: 60	: Total
	: years	: years	: years	: years	: years	: years	:
Utah juniper	161	126	188	211	157	79	922
One-seed juniper	118	147	178	75	142	90	750
Alligator juniper	43	80	105	54	64	48	394
Cypress	24	47	51	56	50	22	250
Total	346	400	522	396	413	239	2,316

Twenty-seven percent of the posts examined were in fences located in the saw-timber zone; 46 percent, in the woodland zone; 15 percent, in the desert; and 12 percent, on irrigated lands. Since most of the early fences were built with the materials nearest at hand, the greater number of the old juniper and cypress fences are located in or adjacent to the woodlands. This accounts for the relatively large number of sample posts occurring in that zone.

It was anticipated that replacements in sample fences might be difficult to recognize. Fortunately, however, only a few replacements were required. Where a replacement was made, the original post was usually found lying nearby. In each case, the original post was measured and recorded as unserviceable, and the new post was disregarded.

METHODS OF ANALYSIS OF DATA

For the purpose of analysis, the posts of each species were first grouped by climatic zones; then each of these four groups was subdivided into 1-inch heartwood diameter classes; and each of these classes, in turn, was subdivided into 5-year length-of-service classes. For each length-of-service class, the following items were computed:

1. Number of posts.
2. Mean heartwood diameter at ground line.
3. Average length of service.
4. Percentage of posts with sapwood entirely decayed.
5. Percentage of posts serviceable, that is, able to withstand lateral pull of 100 pounds.

By plotting the percentages of posts serviceable over years of service, it was possible to draw a series of curves which served as a relative

measure of service life. A better measure would probably be the average age at which posts of a certain classification cease to be serviceable. In this study, however, the data could not be presented in such direct form, because each post was examined but once. Nor was it possible to estimate the number of years the posts that were unable to withstand a pull of 100 pounds had been in that condition, and how long posts now serviceable would remain so. Hence, free-hand curves, based on the percentages of posts serviceable after various lengths of service, or service-life curves, as they may be called, are used herein to aid in drawing conclusions. These curves should be considered as general trends from which specific cases may vary. Several factors are involved in fence-post durability, hence absolute uniformity in service life cannot be precisely evaluated in advance, where posts of the same species and size are used under different conditions. Nevertheless, a number of important relationships were determined with reasonable and practical accuracy. The findings are based entirely on data gathered in Arizona, but they should apply generally to most of the Southwest.

RESULTS

A number of important facts with respect to species, sizes of posts, sapwood, heartwood, site factors, and the requirements for long-life fence posts were ascertained.

Species and Service Life

The comparison made of the service life between species is limited to the woodlands, since it is the only zone where posts of all four species were examined. The results (table 2) show that the mean heart-

Table 2. - Number of posts and mean heartwood diameter by species for fence posts in the woodland zone

Species	Number of posts	Mean heartwood diameter (\pm standard deviation)
		<u>Inches</u>
Utah juniper	334	3.6 \pm 1.1
One-seed juniper	271	3.6 \pm 1.0
Alligator juniper	210	3.7 \pm 1.1
Cypress	250	3.7 \pm 1.2

wood diameters for the three species of juniper and for cypress were almost identical. Diameter classes, therefore, can be disregarded, and one service-life curve is applicable for all posts of each species. The curves for the three species of juniper were also found to be almost identical (fig. 1). It may be concluded that, for all practical purposes, posts of the three native junipers are equally serviceable in the woodland zone. Data from the other zones, although less complete, indicate that this same relationship applies to them also. The service-life curve for cypress is also given in figure 1.

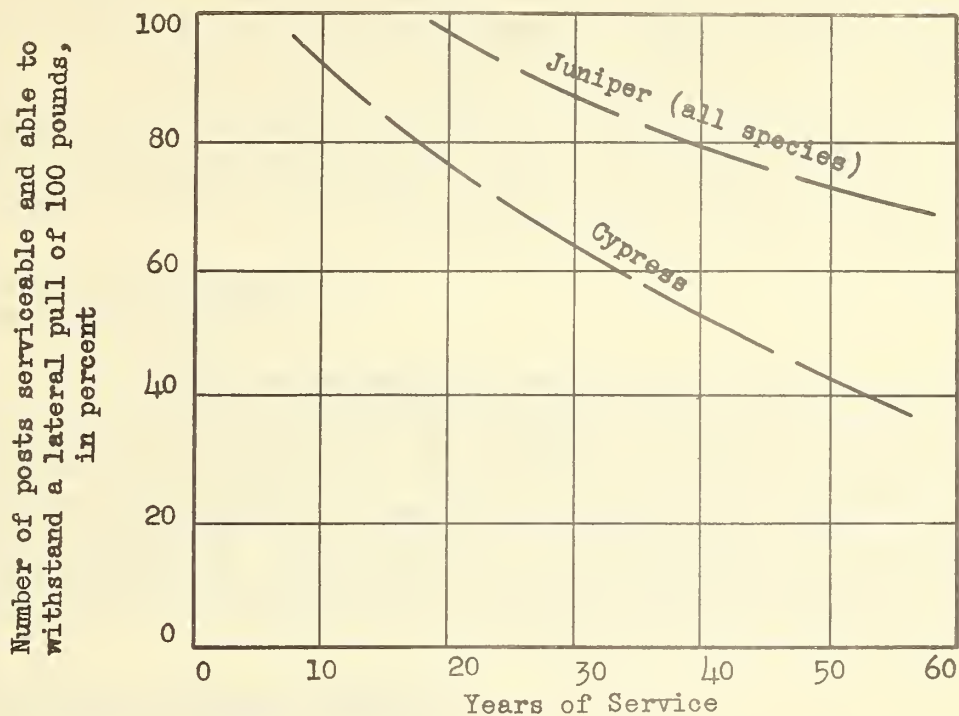


Fig. 1.- Service-life of juniper and cypress fence posts in the woodland zone. (Based on behavior of 815 juniper and 250 cypress posts.)

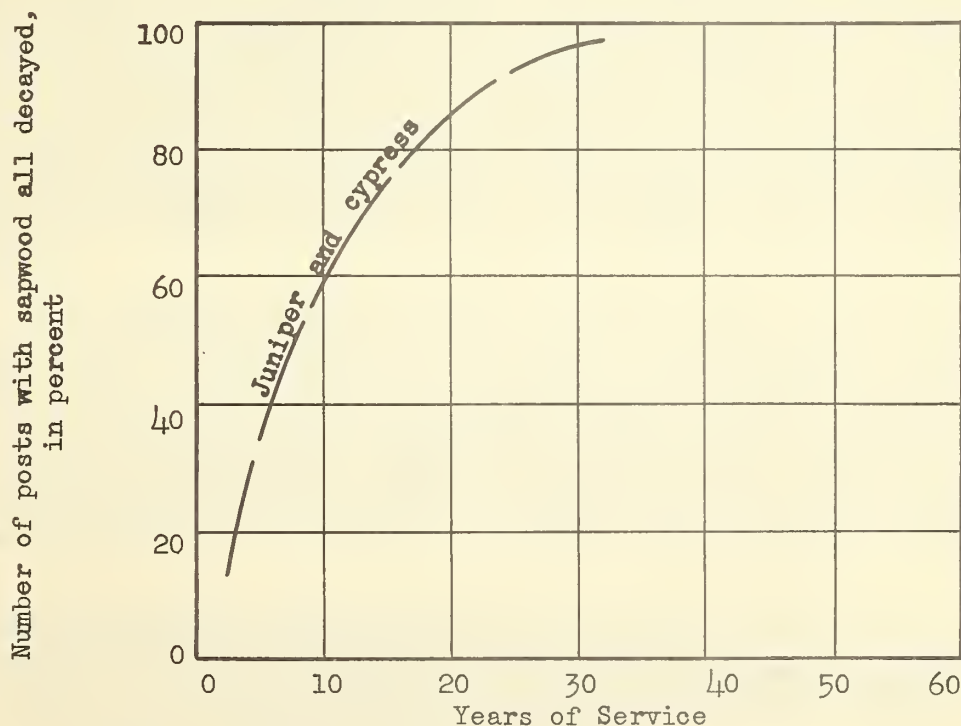


Fig. 2.- Decay of sapwood in relation to length of service for juniper and cypress fence posts combined. (Based on behavior of 2,316 posts from all climatic zones in Arizona.)

Juniper posts show a decided superiority over cypress posts for all ages sampled. At 40 years, 80 percent, and at 50 years, 74 percent of the juniper posts of all diameters and species withstood a lateral pull of 100 pounds, and were otherwise serviceable. Of the cypress posts, 54 percent at 40 years and 43 percent at 50 years showed similar serviceability. These data, in general, confirm the experience of those who have used posts of both juniper and cypress, namely, that although cypress posts sometimes remain serviceable for long periods of years, they are usually less dependable than those of juniper.

Service Life in Relation to Sapwood and Heartwood

It is widely recognized that the sapwood of practically all species of woods, when untreated, is short lived, when used under conditions that favor decay ^{3/}. The cypress and juniper sapwoods are no exception; for in spite of the marked difference in durability of the heartwoods, the sapwoods of juniper and cypress were found to be about equal in durability. The sapwood at the ground level on 60 percent of the sample posts of juniper and cypress was decayed after 10 years of service; and on over 80 percent of the posts, after 20 years of service. (Fig. 2.)

Service Life of Juniper Heartwood

Since the sapwood of untreated juniper and cypress posts is not durable, it is clearly evident that the service life of an individual post depends primarily on the size of its heartwood core. This was found to hold true for juniper posts. For posts with average heartwood diameters varying from 1 to 5 inches at the ground line, the differences in serviceability are very pronounced (see fig. 3). After 40 years of service, 96 percent of the juniper posts with a 5-inch heartwood were serviceable; 86 percent of the 4-inch class; 56 percent of the 3-inch class; 37 percent of the 2-inch class; and only 10 percent of the 1-inch class were serviceable. All juniper posts with more than 5 inches of heartwood withstood the serviceability test, with only few exceptions.

The sapwood of juniper usually decayed in from 5 to 15 years. Instances were found where decay had entered the heartwood. Posts with heartwood decay, however, were so few that it is evident that the heartwood of juniper, when set in the ground, remains sound for many years, even where conditions may be favorable for the decay of many other woods. Ample heartwood, therefore, cannot be overemphasized, and should receive first consideration wherever untreated juniper posts are used in permanent fences.

^{3/} A detailed study of the causes of post failure was not undertaken in this survey. It was noted during the field work, however, that although a few posts in all zones except the saw-timber contained termites, most failures were caused by decay of sapwood.

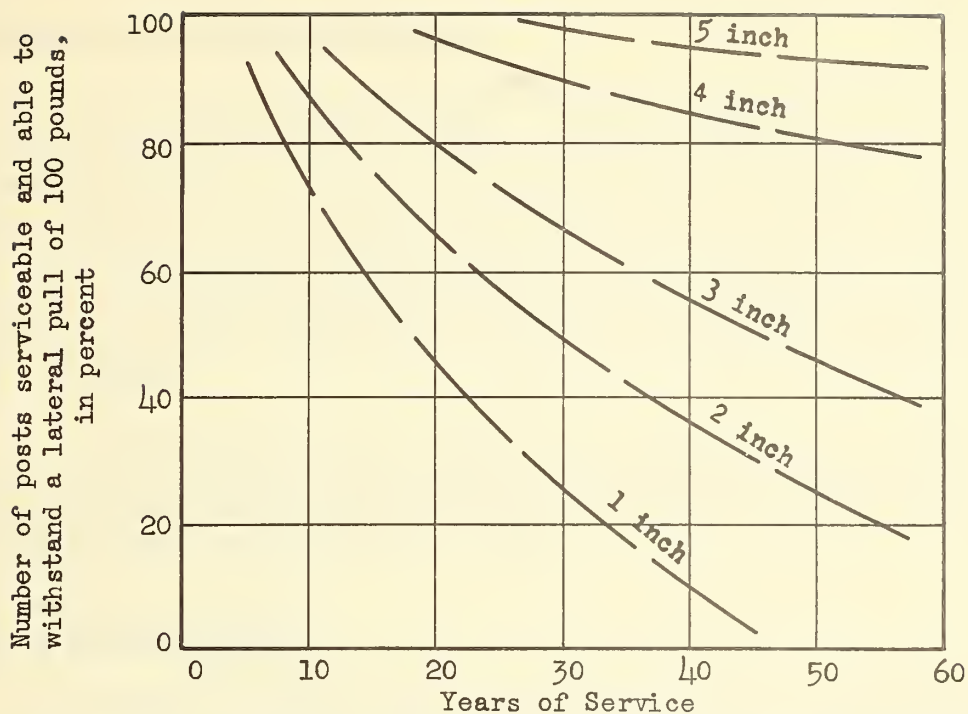


Fig. 3.- Service-life of juniper posts with heartwood diameters varying from 1 to 5 inches at ground level. (Based on behavior of 2,066 posts from all climatic zones in Arizona.)

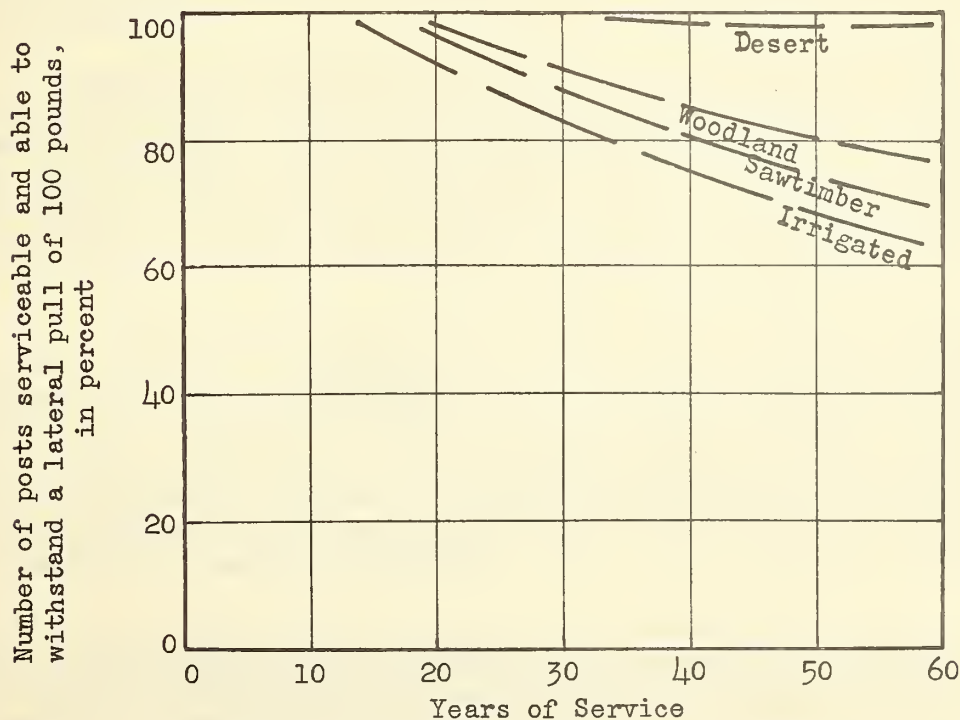


Fig. 4.- Service-life of juniper posts with heartwood 3 inches in diameter and larger at the ground line in the four broad climatic zones. (Based on behavior of 1678 juniper posts

Service Life of Cypress Heartwood

For cypress posts, no clearly defined relationship between size of heartwood core and service life was found. Either cypress heartwood is not so resistant to decay as is juniper, or its durability is determined largely by factors that were not considered in this study. Some users claim that, with cypress posts, seasoning is an important factor, and that well-seasoned posts will last a long time, whereas unseasoned posts are short lived. Should this be true, the inconsistency in relationship between heartwood and service life for cypress would, in part, be explained, since data on seasoning were not available for the posts examined.

Until the factors that control the service life of untreated cypress posts are more fully understood, the use of cypress posts in permanent fences should not be encouraged, unless the posts are given a preservative treatment prior to use.

Site Factors and Service Life of Juniper Posts

As regards juniper posts, on the other hand, a few instances of irregularities in service life of fence posts were noted within the same locality, but none could be consistently explained by recognizable factors within any one zone, such as exposure, slope, drainage, soil, and shading. Some of these factors are undoubtedly important, but because of the interaction of factors involved, the effects of any one could not be determined.

Pronounced differences in service life were found, however, between juniper posts set in the different climatic zones 4/. When all sizes are combined, those with heartwood cores of only 1 inch up to those having 5-inch cores, and beyond 40 years of service, 65 percent of the posts were found serviceable in the irrigated zone, 70 percent and 79 percent, respectively, in the saw-timber and woodland zones, and over 90 percent were found serviceable in desert-zone fences.

The results show, among other things, that conditions for decay of juniper are least favorable in the desert zone, intermediate in the woodland zone, and more favorable in the saw-timber zone and on irrigated lands. They also show that, in connection with decay, moisture is the primary factor, for in the saw-timber and irrigated zones, where conditions are more favorable to decay, soil moisture is also most abundant, whereas in the desert zone, where decay hazards are lowest, soil moisture is usually deficient.

4/ All cypress fence posts examined were located in the woodland zone, which made it impossible to draw a comparison of the service-life of that species in the different zones.



HEARTWOOD REQUIREMENTS FOR JUNIPER POSTS

The data in this investigation have proved several points: (a) The sapwood of juniper, as well as of cypress, is not durable (fig. 2); (b) the heartwood core of juniper posts must be depended upon to support the fence; and (c) a heartwood core of 2 inches or less in diameter is either not large enough to resist a lateral pull of 100 pounds or is not of sufficient mass to remain sound over a long period of years. It is evident, therefore, that juniper posts with heartwood cores 2 inches and less in diameter, regardless of the width of the sapwood, are not suitable for permanent fences.

In order to check this conclusion, the posts with 1- and 2-inch heartwood cores were eliminated from consideration, and only those with 3-inch and larger cores were reanalyzed by zones. The results, which are graphically given in figure 4, show that after 40 years of service, 98 percent of the juniper posts with heartwood cores 3 inches and greater in diameter were able to resist a lateral force of 100 pounds, to which a fence may be subjected, and otherwise are serviceable when used in the desert zone of low decay hazard; that 85 percent of posts of similar service length and size are serviceable when used in the woodland zone; 81 percent in the saw-timber zone; and 75 percent on irrigated lands, where decay conditions may be most severe. These facts indicate the great durability of the heartwood of the Utah, one-seed, and alligator junipers of the Southwest, when used as posts in contact with soil.

MINIMUM SPECIFICATION FOR JUNIPER POSTS

In translating these results into practical post specifications, the question arises, What minimum permissible heartwood diameter should be specified for juniper fence posts to be used in each climatic zone, in order to insure satisfactory service in permanent fences?

As a basic standard, a utility of 80 percent after 40 years of service is herein used as the minimum. This represents a high standard for fence-post behavior, and it should satisfactorily meet the needs of most users, and at the same time there is recognized the factor of obsolescence, which is inherent in many fence locations.

It is obvious that posts with a heartwood core of 2 inches or less at the ground line do not render satisfactory service in any of the four climatic zones, and that posts with a heartwood core of 5 or more inches at the ground line render service far above this minimum standard in all zones. (See fig. 3.) Hence, the minimum heartwood diameter for each zone must be determined largely by the behavior of the posts that fall into the 3- and 4-inch heartwood-diameter classes. Accordingly, the data for the 3- and 4-inch classes were again reanalyzed by zones. It was found that posts with 3 inches of heartwood at ground line would meet the minimum standard for fences in the desert



zone; that $3\frac{1}{2}$ inches would be required in the woodland zone, and that 4 inches would be necessary in both the saw-timber and irrigated zones. These minimum permissible heartwood diameters, with their corresponding butt heartwood diameters, are presented in table 3.

Table 3. - Minimum heartwood diameters required of juniper posts to insure a utility of 80 percent after 40 years of service

Zone in which posts may be used	Minimum diameter of heartwood core	
	At ground line: At butt [*]	
	<u>Inches</u>	<u>Inches</u>
Desert	3.0	3.5
Woodland	3.5	4.0
Saw timber	4.0	4.5
Irrigated	4.0	4.5

* It is assumed that posts will be placed approximately 2 feet into the ground.

Although these minimum requirements are based entirely on data pertaining to round juniper posts, they should also be applicable to posts split from larger trees. If used for split posts, the area of the heartwood of such posts should be equal to the area computed on the basis of the minimum diameters for round posts given in table 3.

SUMMARY

A systematic study was made of fence posts during 1939, to determine the service life of untreated juniper and cypress posts in Arizona. In all about 2,300 posts in 97 widely distributed fences were examined, and serviceability was determined by their ability to withstand a lateral pull of 100 pounds.

The following facts have been ascertained:

1. Untreated cypress posts are moderately durable, but are inconsistent in their behavior, because of the variable resistance of their heartwood to decay. When used in permanent fences, cypress posts should be given a preservative treatment, to insure satisfactory service.
2. Untreated juniper posts uniformly render long service, owing to the ability of their heartwood to remain sound for a very long period of years, even where conditions are favorable for the decay of many other woods.

3. Posts of the three native species of junipers (Utah, one-seed, and alligator) are, for all practical purposes, equally serviceable when they contain the same amount of heartwood and are used under similar conditions.
4. The service life of juniper posts differs, as determined by temperature and moisture. Their service life is best in the desert zone, intermediate in the woodland zone, and poorest in the saw-timber zone and on irrigated lands.
5. Owing to the lasting qualities of juniper heartwood, there is a close relation between the size of the heartwood core and service life. In order to compensate for the differences in service life in the various zones of use, the heartwood requirements should be varied accordingly.
6. In order to insure a utility of 80 percent after 40 years of service, juniper posts should contain a minimum heartwood diameter at the butt of $3\frac{1}{2}$ inches for the desert zone, 4 inches for the woodland zone, and $4\frac{1}{2}$ inches for the saw-timber and irrigated zones.

